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Renewable and Sustainable Energy Reviews
11 (2007) 183–209
RENEWABLE & SUSTAINABLE ENERGY REVIEWS
www.elsevier.com/locate/rser

Past, present and future status of electricity in Turkey and the share of energy sources

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Received 20 December 2004; accepted 7 February 2005

Abstract

With a young and growing population, low per capita electricity consumption, rapid urbanization and—until recently—strong economic growth, Turkey for nearly two decades has been one of the fastest growing power markets in the world. Prior to Turkey's recent severe economic difficulties, Turkey's electricity consumption had been growing much faster than its production. It forces Turkey make a rapid action to supply electricity demand. Installed power generation capacity in Turkey reached about 31.84 GW in 2002. However, the growth in electricity generation has remained below the electricity demand, which made Turkey a net importer of electricity since, 1996. Projections show that Turkey's electricity consumption would continue over the next 15 years.

Keywords: Electricity; Turkey; Hydroelectric; Natural gas; Thermal power

Contents

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1364-0321/$ - see front matter
doi:10.1016/j.rser.2005.01.003

1. Introduction

Turkey is located between Europe and Asia, bordering the Mediterranean, Aegean and Black Seas. Turkey is striving to make good use of its geographic location as a transit country. Turkey is an important candidate to be the 'Energy Corridor', for the transmission of the Middle East, Caspian area and Asia Country's rich oil and natural gas resources to the Mediterranean and to the demand centers of the West.

Turkish economy, the world's 16th largest economy, is a dynamic and emerging. In 2001, Gross National Product (GNP) was realized as 148 Billion USD. The gross national product per capita was about 2500 USD [1]. In 2002, GNP reached about 180 billion USD, which corresponds to 2586 USD per capita. In 2003, GNP and per capita is expected to increase to 239 billion USD and 3374 USD, respectively [2]. Population of Turkey is about 70 million, almost 30% of whom are under 15 years old and 52% of the population lives in urban centers [3]. The population growth rate is 1.6%, the highest among IEA countries and it is assumed to increase by about 1.5% per year in the next 20 years. Total population is expected to exceed 83 million in 2022 [4]. The share of exports in GNP rose from slightly above 4% in 1981 to almost 20% in 2002, while imports rose from about 12% to almost 28%. The economy has also undergone a significant shift away from agriculture towards the industrial and especially the services sector in the last three decades, although some 40% of the active population is still employed in agriculture. The net effect of all these factors is that Turkey's energy demand has grown rapidly almost every year and is expected to continue growing.

The relationship among the primary energy consumption, Gross Domestic Product (GDP), population, electricity production and consumption in Turkey has been given in Table 1. As shown in the Table, during the last 10 years, while population increased 1.92%, GDP and Total Primary Energy Consumption increased 3.03 and 3.38, respectively. Net Electricity Consumption, Net Electricity Production and Gross Electricity Production increased about 10% during the same period.

Economic growth is the most important driver of energy demand. Total final consumption of electricity has been shown in many countries to be correlated with economic activity. The other reasons for increase of electricity demand are high birth rates, higher living standards, industrialization and young populations. Like in the other developing countries, in Turkey, the demand for energy and electricity is growing rapidly due to the social and economic development and increase of the population of the country [5,6].

Table 1
Primary energy consumption, GDP, population, electricity production and consumption in Turkey [47,49]

	Years							Average annual percent change (%)
	1990	1995	1998	1999	2000	2001	2002	1990–2002
Population (millions)	56.20	61.55	64.79	65.82	67.46	68.61	69.20	1.92
GDP (1995 billion US$)	144.57	169.32	200.85	191.39	205.47	190.29	197.10	3.03
Total Primary Energy Consumption	53.00	61.86	72.23	70.98	77.49	72.46	74.55	3.38
Net Electricity Consumption (TWh)	46.82	67.39	87.70	91.20	98.30	97.07	103.30	10.05
Net Electricity Production (TWh)	54.23	81.86	105.50	110.70	118.70	116.25	122.11	10.43
Gross Electricity Production (TWh)	57.50	86.20	111.00	116.40	124.90	122.70	129.40	10.42
Total Primary Energy Consumption/GDP (ktoe/1995 thousand US$)	366.60	365.34	359.62	370.87	377.14	380.79	378.23	0.26
Total Primary Energy Consumption/ Population (ktoe/per capita)	943.06	1005.04	1114.83	1078.40	1148.68	1056.11	1077.31	1.18
Net Electricity Consumption/GDP (kWh/1995 thousand US$)	323.86	398.00	436.64	476.51	478.42	510.12	524.10	5.21
Net Electricity Consumption/ Population (kWh/per capita)	833.10	1094.88	1353.60	1385.60	1457.16	1414.81	1492.77	6.83
Gross Electricity Production of which: renewables (TWh)	23.23	35.85	42.57	34.93	31.15	24.30	33.97	3.85
Gross Electricity Production Renewables/ Gross Electricity Production (%)	40.40	41.60	38.30	30.00	24.90	19.80	26.20	−2.93

There is a causal relationship between energy consumption and income and it is a wellstudied topic in the literature of energy economics. In their pioneering study, Kraft and Kraft [7] found a relationship between GNP and energy consumption for the United States. They used annual data for the 1947–1974 periods for their study. The importance of energy in economic development has been recognized almost universally; historical data attests to a strong relationship between the availability of energy, economic activity, and improvements in standards of living and overall social well-being [8,9]. More recently, Ceylan and Ozturk [10], Ozturk et al. [11] and Canyurt et al. [12], estimated energy demand and electricity consumption for Turkey using genetic algorithm. Three of the studies

showed that there is a casual relationship between energy demand, electricity consumption, economic growth and social development. However, Akarca and Long [13] pointed out that the Kraft–Kraft results are spurious by changing the time period by 2 years. Other studies utilizing different time periods and different techniques have either confirmed or contradicted Kraft–Kraft results [14–17].

The relationship between electricity consumption and GNP in Turkey has been erratic in the past, as Fig. 1 indicates. Net Electricity Consumption (NEC) increased steadily during the period of 1975–2000. There is a slight decrease between 2000 and 2001. On the other hand, GNP decreased three times (1979, 1993 and 2001) due to economic crisis. Most of the studies on the relationship between the energy consumption and economic indicators (such as GNP, import, export) were for the long time period. It could be argued that NEC of Turkey has not been sensitive to economic crisis since the effect of the economic crisis disappears in the period of one or two years.

With Total Primary Energy Supply (TPES) growth rates of 4% to over 5% per annum and Total Final Consumption (TFC) growth of around 4% over the last three decades, Turkey is among the fastest growing energy markets in the world, and the fastest in the IEA. The government expects demand growth to accelerate in the coming two decades, with an average annual TFC growth rate of 8% between 2000 and 2005, 5.8% between 2005 and 2010, and 5.9% between 2010 and 2020. However, this demand growth occurs from a low base. Turkey's per capita TPES was 1.19 Mtoe in 1999, and is expected to grow to 3.65 in 2020. Even in the year of 2020, the figure will be still significantly below the IEA's overall per capita TPES in 1973 of 4.61 and in 1998 of 5.10 [3].

From 1971 to 2001, the electricity consumption of Turkey increased from 268 kWh/per capita in 1970 to 1849 kWh/per capita in 2001. In 30 years, it increased about 690% times as shown in Table 2. In Table, the countries are selected for comparison since some similarities exist. Italy is one of the European Union countries like Turkey at Mediterranean Belt. Spain and Portugal were similar countries to Turkey before they

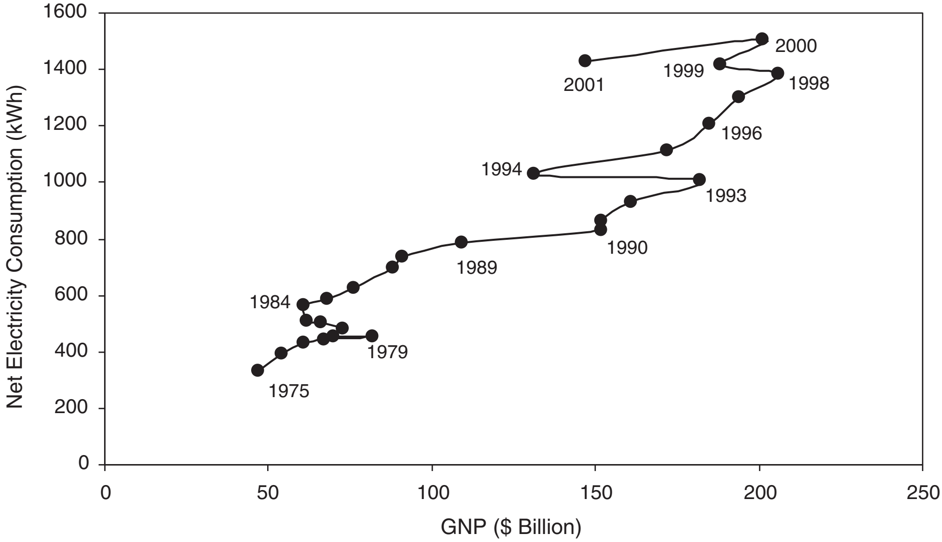


Fig. 1. The relationship between electricity consumption and GNP in Turkey.

Table 2
Net Electricity Consumption per capita of some countries (kWh/per capita) [48]

Years	Austria	Germany	Italy	Portugal	South Korea	Spain	United Kingdom	Turkey
1971	3497	4290	2340	938	321	1756	4592	268
1975	4056	5001	2704	1201	562	2305	4838	393
1980	5066	6063	3401	1744	859	2909	5068	554
1985	5663	6760	3700	2112	1243	3287	5249	723
1990	6471	6942	4431	2883	2202	3900	5750	1011
1995	6723	6636	4867	3445	4040	4375	5978	1386
2000	7497	6530	5559	4466	5575	5750	6511	1901
2001	7990	6053	5800	4552	5613	5998	6687	1849

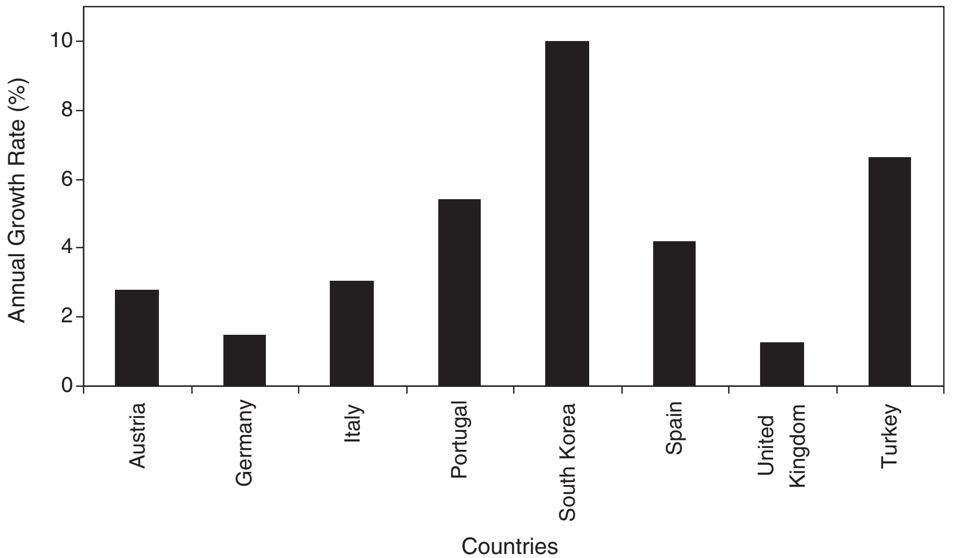


Fig. 2. Annual average electricity consumption per capita growth rate for different countries between 1971 and 2001 [48].

were not members of the union. Korea have rapid growth rate like Turkey. In addition, United Kingdom, Germany and Austria take part in developed countries. Turkey's average electricity consumption per capita grow rate was about 6.65% between 1971 and 2001 and it was about 8% from 1985 to 2001 (see Tables 1, and 2, Fig. 2). For the period of 1971 and 1995, the average annual electricity consumption per capita growth was 3.8% for the OECD area and 3.8% for the world [3]. The transmission and distribution losses steadily increased in Turkey during the period of 1985 to 2001. It has been increased 4345.9–23,328.7 GWh. The annual share of the transmission and distribution losses in total consumption was average of 15.88 and 19.3% in 2001 (see Table 3). The most important figure for electricity, should be mentioned, is losses. The transmission and distribution losses were 4346 GWh in 1985 and increased to 23,329 GWh in 2001. The average losses were about 16% of net electricity generation during 1985–2001 (see Table 3).

Table 3
Annual development of electricity generation-consumption and losses in Turkey (GWh) [49]

Years	Gross production	Increase (%)	Net production	Imports	Supplied to the network[a]	Transmission and distribution losses	%	Exports[b]	Net consumption	Increase (%)
1985	34,218.9	–	31,912.1	2142.4	34,054.5	4345.9	–	–	29,708.6	–
1986	39,694.8	16.0	36,879.8	776.6	37,656.4	5446.7	14.5	–	32,209.7	8.4
1987	44,352.9	11.7	41,745.2	572.1	42,317.3	5620.0	13.3	–	36,697.3	13.9
1988	48,048.8	8.3	45,648.8	381.2	46,030.0	6308.5	13.7	–	39,721.5	8.2
1989	52,043.2	8.3	48,808.7	558.5	49,367.2	6247.2	12.7	–	43,120.0	8.6
1990	57,543.0	10.6	54,231.6	175.5	54,407.1	6680.3	12.3	906.8	46,820.0	8.6
1991	60,246.3	4.7	56,591.1	759.4	57,350.5	7561.2	13.2	506.4	49,282.9	5.3
1992	67,342.2	11.8	63,104.9	188.8	63,293.7	8994.8	14.2	314.2	53,984.7	9.5
1993	73,807.5	9.6	69,864.4	212.9	70,077.3	10,251.6	14.6	588.7	59,237.0	9.7
1994	78,321.7	6.1	73,782.6	31.4	73,814.0	11,843.0	16.0	570.1	61,400.9	3.7
1995	86,247.4	10.1	81,858.6	–	81,858.6	13,768.8	16.8	695.9	67,393.9	9.8
1996	94,861.7	10.0	90,084.4	270.1	90,354.5	15,854.8	17.5	343.1	74,156.6	10.0
1997	103,295.8	8.9	98,245.6	2492.3	100,737.9	18,581.9	18.4	271.0	81,885.0	10.4
1998	111,022.4	7.5	105,499.2	3298.5	108,797.7	20,794.9	19.1	298.2	87,704.6	7.1
1999	116,439.9	4.9	110,701.9	2330.3	113,032.2	21,545.0	19.1	285.3	91,201.9	4.0
2000	124,921.6	7.3	118,697.6	3791.3	122,488.9	23,755.9	19.4	437.3	98,295.7	7.8
2001	122,724.7	−1.8	116,252.1	4579.4	120,831.5	23,328.7	19.3	432.8	97,070.0	−1.2

[a]Supplied to the network, net production + import.
[b]As the export is made on delivery at border basis, its losses are included in the section for transmission network losses.

Table 4a
Network losses and sectoral breakdown of Net Electricity Consumption in selected countries (TWh) (2001) [50]

Countries	Residential	Commer-cial and official	Industrial	Agricultural	Transpor-tation	Energy	Total	Losses
Austria	15.75	12.54	23.19	1.22	3.78	0.96	57.43	3.3
Germany	139.09	108.73	230.35	7.53	15.97	15.19	516.86	25.8
Italy	61.55	59.24	143.21	5.16	8.57	7.77	285.49	19.4
Portugal	10.63	12.01	16.16	0.78	0.36	0.60	40.54	4.1
South Korea	39.21	70.76	132.16	5.99	2.26		250.37	17.9
Spain	49.69	51.27	90.27	5.18	4.56	6.34	207.30	20.3
United Kingdom	115.34	92.62	112.43	4.58	8.84	9.62	343.43	32.2
Turkey	23.56	22.90	45.00	3.20	0.66	1.75	97.07	23.3
OECD	2492.31	2320.70	3123.58	82.98	107.81	236.48	8372.14	597.8

Table 4b
The rate of network losses and sectoral breakdown of Net Electricity Consumption in selected countries (2001) [50]

Countries	Residential (%)	Commercial and official (%)	Industrial (%)	Agricultural (%)	Transpor-tation (%)	Energy (%)	Losses (%)
Austria	27.42	21.84	40.38	2.12	6.58	1.67	5.75
Germany	26.91	21.04	44.57	1.46	3.09	2.94	4.99
Italy	21.56	20.75	50.16	1.81	3.00	2.72	6.80
Portugal	26.22	29.63	39.86	1.92	0.89	1.48	10.11
South Korea	15.66	28.26	52.79	2.39	0.90	0.00	7.15
Spain	23.97	24.73	43.55	2.50	2.20	3.06	9.79
United Kingdom	33.58	26.97	32.74	1.33	2.57	2.80	9.38
Turkey	24.27	23.59	46.36	3.30	0.68	1.80	24.00
OECD	29.77	27.72	37.31	0.99	1.29	2.82	7.14

Network losses and sectoral breakdown of Net Electricity Consumption and their rate for selected countries was given in Table 4a and b, respectively. Industry, residential and commercial-official sectors are the biggest energy consumers in Turkey. As could be seen in the Tables, about half of the total electricity is consumed by industry and electricity losses are nearly equal to residential or commercial and official electricity uses with 23.3 TWh or 24%. Turkey has the highest record for electricity losses among the selected countries given in Table 4a and b. The total electricity losses of Turkey in 2001 were 24% and it was 3.36 times higher than the average of OECD with 7%. Therefore, it is very important for Turkey to concentrate on the electricity losses, decrease the electricity to acceptable level.

2. Brief historical development of electricity in Turkey

The electricity industry in Turkey dates back to 1902, when a 2 kW hydropower system was connected to a water mill in Tarsus. The first larger-scale power plant was built in Istanbul in 1913. The whole installed capacity was 29,664 kW when Turkish Republic was

established in 1923 and the production was 45 GWh/year in those years and the electricity was only available in three cities, namely Istanbul, Adapazari and Tarsus. The first Turkish electricity company, Kayseri ve Civarı Elektrik Turk Elektrik Inc., was established in 1926. At the end of the 1920s, there were 48 power plants (74.8 MW) producing 106.3 GWh electricity and per capita electrical consumption was 6.2 kWh [18]. In 1935, several government institutions with authority relating to electricity production were established. These included the Electric Power Resources Survey and Development Administration (Elektrik Isleri Etut Idaresi, EIE), which still exist today. EIE carries out surveys and preparatory work to identify hydro potential, plans and prepares dam and hydro plant projects. EIE is also involved in studying energy conservation and the use of new and renewable energy resources [3].

At the beginning of the 1950s, installed capacity was about 408 MW generating 789.5 GWh electricity, only the 23% of the population used electricity, while per capita consumption increased to 32 kWh [3]. The Ministry of Energy and Natural Resources of Turkey (MENR) was established in December 1963, and was responsible for Turkey's energy policy. This was followed by passing the law creating the Turkish Electricity Administration Commission (TEK), which would create a monopoly in the Turkish electricity sector at all stages. All generation assets were passed to TEK except the ones that belong to Cukurova Elektrik T.A.S. and Kepez ve Antalya Havalisi Elektrik Santralleri T.A.S. The transmission and distribution business, which was managed by the municipals, were left to the local governments [19].

By 1970, installed capacity had increased to about 2234.9 MW, and both growing power consumption and the government's electrification plans required more coherent organization of the power industry. At that time, only 7% of all villages were electrified. As a consequence, the government established the Turkish Electricity Authority (Turkiye Elektrik Kurumu, TEK) as a fully state-owned and state run entity that year. Installed hydroelectric power plants provided approximately 32% of the electrical power during 1970. In contrast, during the same year, 68% of the installed electrical power came from thermal power plants (see Fig. 3). Up to 1971, the power plants were operated by some governmental organizations and institutions established with a special law. According to a law issued in 1971, Turkish Electricity Authority (TEK) was responsible as a whole for the generation and distribution of electricity throughout the country [20]. In 1982, electrification had reached about 60% of all villages, and installed capacity had grown to 6639 MW. All plants and networks owned by municipalities and unions were transferred to TEK that year [3]. Variation of electricity generation in Turkey shows a sudden and unpredictable change. From 1973 to 1982, hydroelectric generation showed a steady increase though thermal power generation was almost constant (see Fig. 4). The reason could be the first oil crisis. Turkey was severely affected by the oil price increase of 1973. In the years following the first oil crisis, economic conditions deteriorated, with high unemployment, a nearly fivefold increase in the balance of payments deficit between 1973 and 1979, large external debt and annual inflation rates exceeding 100% in 1980. It forced Turkey to use the national and renewable energy source, hydraulic. After 1982, the effect of oil crisis was recovered and again Turkey started to use thermal power.

Although the wind of the privatization studies has blown since 1984, the private sector was not so much active on this matter until 1985 because the details of the privatization were not examined in the first law issued [20]. In 1987, construction of Karakaya dam (1800 MW) and in 1992 construction of Ataturk dam (2400 MW) were finished and they

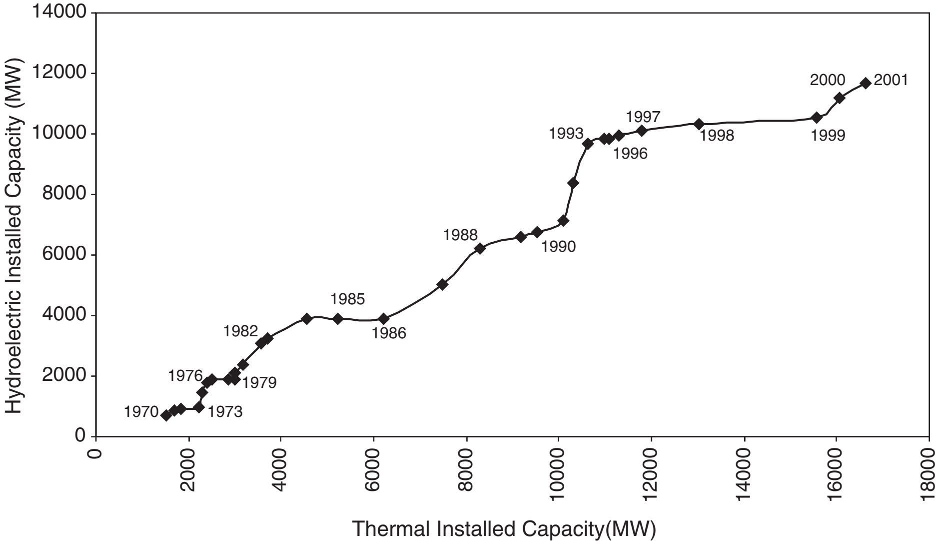


Fig. 3. Variation of installed hydraulic and thermal power capacity from 1970 to 2001.

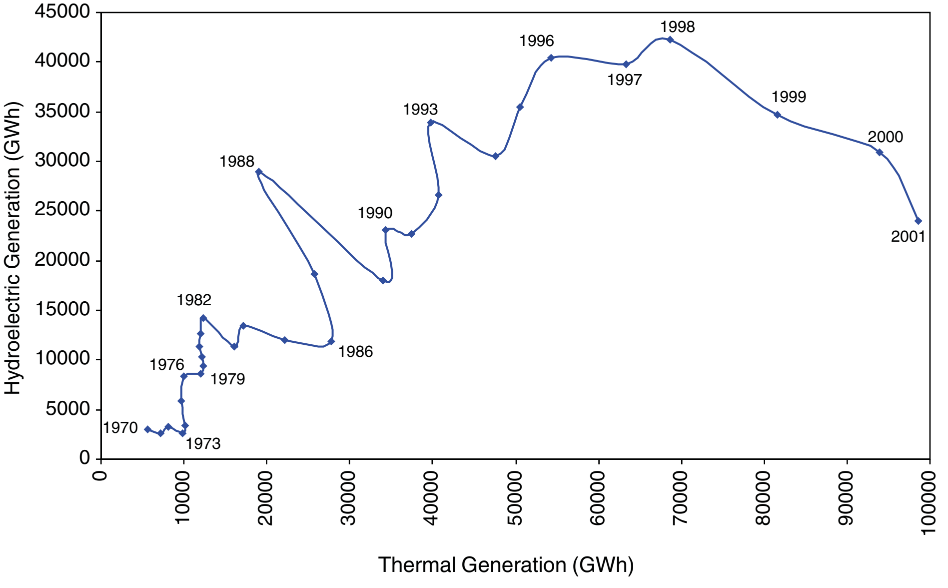


Fig. 4. Variation of hydraulic and thermal power generation from 1970 to 2001.

started producing electricity. Therefore, the share of hydroelectric generation increased. From 1989 to 1998, electricity generation from hydraulic and thermal increased almost linear. After 1998, hydroelectric generation started decreasing while thermal electricity generation increases (see Fig. 4 and Table 5). After 1987, Turkey started importing natural gas and most of it used for electricity generation [21–23]. During 1986–1993, the

Table 5
Annual development of installed capacity and generation in Turkey [49]

Years	Installed capacity (MW)					Generation (GWh)				
	Thermal	Hydro	Geothermal and wind	Total	Increase (%)	Thermal	Hydro	Geothermal and wind	Total	Increase (%)
1970	1509.5	725.4	–	2234.9	–	5590.2	3032.8	–	8623.0	–
1971	1706.3	871.6	–	2577.9	15.3	7170.9	2610.2	–	9781.1	13.4
1972	1818.7	892.6	–	2711.3	5.2	8037.7	3204.2	–	11,241.9	14.9
1973	2207.1	985.4	–	3192.5	17.7	9821.8	2603.4	–	12,425.2	10.5
1974	2282.9	1449.2	–	3732.1	16.9	10,121.2	3355.8	–	13,477.0	8.5
1975	2407.0	1779.6	–	4186.6	12.2	9,719.2	5903.6	–	15,622.8	15.9
1976	2491.6	1872.6	–	4364.2	4.2	9,908.0	8374.8	–	18,282.8	17.0
1977	2854.6	1872.6	–	4727.2	8.3	11,972.3	8592.3	–	20,564.6	12.5
1978	2987.9	1880.8	–	4868.7	3.0	12,391.3	9334.8	–	21,726.1	5.6
1979	2987.9	2130.8	–	5118.7	5.1	12,218.3	10,303.6	–	22,521.9	3.7
1980	2987.9	2130.8	–	5118.7	0.0	11,927.2	11,348.2	–	23,275.4	3.3
1981	3181.3	2356.3	–	5537.6	8.2	12,056.7	12,616.1	–	24,672.8	6.0
1982	3556.3	3082.3	–	6638.6	19.9	12,384.8	14,166.7	–	26,551.5	7.6
1983	3695.8	3239.3	–	6935.1	4.5	16,004.1	11,342.7	–	27,346.8	3.0
1984	4569.3	3874.8	17.5	8461.6	22.0	17,165.1	13,426.3	22.1	30,613.5	11.9
1985	5229.3	3874.8	17.5	9121.6	7.8	22,168.0	12,044.9	6.0	34,218.9	11.8
1986	6220.2	3877.5	17.5	10,115.2	10.9	27,778.6	11,872.6	43.6	39,694.8	16.0
1987	7474.3	5003.3	17.5	12,495.1	23.5	25,677.2	18,617.8	57.9	44,352.9	11.7
1988	8284.8	6218.3	17.5	14,520.6	16.2	19,030.8	28,949.6	68.4	48,048.8	8.3
1989	9193.4	6597.3	17.5	15,808.2	8.9	34,041.0	17,939.6	62.6	52,043.2	8.3
1990	9535.8	6764.3	17.5	16,317.6	3.2	34,314.9	23,148.0	80.1	57,543.0	10.6
1991	10,077.8	7113.8	17.5	17,209.1	5.5	37,481.7	22,683.3	81.3	60,246.3	4.7
1992	10,319.9	8378.7	17.5	18,716.1	8.8	40,704.6	26,568.0	69.6	67,342.2	11.8
1993	10,638.4	9681.7	17.5	20,337.6	8.7	39,779.0	33,950.9	77.6	73,807.5	9.6
1994	10,977.7	9864.6	17.5	20,859.8	2.6	47,656.7	30,585.9	79.1	78,321.7	6.1
1995	11,074.0	9862.8	17.5	20,954.3	0.5	50,620.5	35,540.9	86.0	86,247.4	10.1
1996	11,297.1	9934.8	17.5	21,249.4	1.4	54,302.8	40,475.2	83.7	94,861.7	10.0
1997	11,771.8	10,102.6	17.5	21,891.9	3.0	63,396.9	39,816.1	82.8	103,295.8	8.9
1998	13,021.3	10,306.5	26.2	23,354.0	6.7	68,702.9	42,229.0	90.5	111,022.4	7.5
1999	15,555.9	10,537.2	26.2	26,119.3	11.8	81,661.0	34,677.5	101.4	116,439.9	4.9
2000	16,052.5	11,175.2	36.4	27,264.1	4.4	93,934.2	30,878.5	108.9	124,921.6	7.3
2001	16,623.1	11,672.9	36.4	28,332.4	3.9	98,562.8	24,009.9	152.0	122,724.7	−1.8
2002	19,568.5	12,240.9	36.4	31,845.8	12.4	95,563.1	33,683.8	152.6	129,399.5	5.4

installation of hydroelectric system increased steadily. After 1993, there is not recognizable change for the hydroelectric installation. On the other hand, thermal power plants installation showed a rapid increase after 1997 due to installation of natural gas power plants (see Fig. 3 and Table 5).

In 2002, Turkey's installed power generation capacity reached 31,845.8 MW, and 99.9% of its population was connected to the electricity grid. From 1970 to 2002, average installed electricity and generation grow rate was 8.83 and 8.90%, respectively (see Table 5). In 1993, the share of installed hydroelectric and thermal power plants was (33,950.9 GWh) 46.1 and 53.8% (39,779 GWh), respectively. On the other hand, electricity production of hydroelectric decreased to 19.6% (24,009.9 GWh) while the share of thermal power production increased to 80.30% (98,562.8 GWh) in 2001 (see Tables 6 and 7). Use of natural gas for electricity generation decreased the share of hydroelectric in the total electricity during 1998–2002.

3. Legal regulations in the electricity sector

Today, Turkey's electricity supply industry is dominated by large, publicly-owned companies Directorate-General of Turkish Electricity Transmission (TEIAS), Turkish Electricity Distribution Corporation (TEDAS) and Electricity Production Company (EUAS). Breakdown of installed and generation of electricity in Turkey is given in Tables 8 and 9. The share of the Electricity Production Company in total installed capacity in total was 14,729.3 MW in 1990 and increased to 17,779.3 MW in 2001. However, its share was decreased from 90% in 1990 to 63% in 2001. Installed capacity of the auto production, subsidiaries of Turkish Electricity Company and production companies are 3373.9 MW (12%), 3284.0 MW (12%) and 2337.8 MW (8%) respectively (see Table 8). For the electricity generation, the picture was the same in the last 10 years. In 1990, the Turkish Electricity Production Company was almost monopoly with the electricity generation of 52,854 MW. Although its generation increased to 67,469 MW in 2001, its share was decreased from 92% in 1990 to 55% in 2001 (see Table 9).

Law 3096, named 'Respecting Authorization to Institutions other than the TEK for Generation, Transmission, Distribution and Trade of Electricity', was published in the Official Gazette on 19 November 1984, and numbered as 18,610. This allowed the private sectors to build and operate the electricity generation, transmission and distribution systems for the first time in the history of Turkish Republic. The Built Operate and Transfer (BOT) model was first introduced in 1984. Turkey was one of the first countries to conceive the BOT model as an alternative in implementing power projects to meet the growing need for public service investment [19]. Under this model, private investors build and operate private sector generation facilities for several years, then, finally, transfer ownership (in this case) to the state. The electric power produced by these projects could be sold to the national grid, the state-owned electricity authority, or even to a private end user. Decree number 85/9799, issued in 1985, is a legal document that gave the details of law no. 3096 and put autoproduction into practice. The decree of autoproduction has been revised several times to date in order to clear applications and extend the application area [19]. On the other hand, in order to provide financial support to power projects and to maintain stability of electrical energy prices, electrical energy fund (EEF) was established in March 1990, by law no. 3613. The regulation relating to the application of EEF law was put into effect in 1991 [24].

Table 6
Annual development of Turkey's gross electricity generation by primary energy resources (GWh) [49]

Years	Hard coal	Lignite	Total	Fuel oil	Diesel oil	LPG	Naph-tha	Total	Natural gas	Renew. and waste	Ther-mal total	Hydro	Geo-thermal	Wind	General total
1970	1382.3	1442.2	2824.5	2336.5	263.5	–	–	2600	–	165.7	5590.2	3032.8	–	–	8623
1975	1427.4	2685.9	4113.3	4700	685.9	–	–	5385.9	–	220	9719.2	5903.6	–	–	15,622.8
1980	911.7	5048.6	5960.3	5222.8	608.4	–	–	5831.2	–	135.7	11,927.2	11,348.2	–	–	23,275.4
1981	892.3	5244.1	6136.4	5195.5	614.8	–	–	5810.3	–	110	12,056.7	12,616.1	–	–	24,672.8
1982	912.8	5528.4	6441.2	5305.8	637.8	–	–	5943.6	–	–	12,384.8	14,166.7	–	–	26,551.5
1983	787.2	7789.8	8577	6348.4	1078.7	–	–	7427.1	–	–	16,004.1	11,342.7	–	–	27,346.8
1984	705.6	9412.7	10,118.3	6710.6	336.2	–	–	7046.8	–	–	17,165.1	13,426.3	22.1	–	30,613.5
1985	710.3	14,317.5	15,027.8	7028.6	53.4	–	–	7082	58.2	–	22,168	12,044.9	6	–	34,218.9
1986	772.8	18,664.5	19,437.3	6941.3	59.3	–	–	7000.6	1340.7	–	27,778.6	11,872.6	43.6	–	39,694.8
1987	627.8	17,025.7	17,653.5	5418.1	77.5	–	–	5495.6	2528.1	–	25,677.2	18,617.8	57.9	–	44,352.9
1988	345.3	12,141.3	12,486.6	3248.7	56	–	–	3304.7	3239.5	–	19,030.8	28,949.6	68.4	–	48,048.8
1989	317	19,952.5	20,269.5	4209.2	38.3	–	–	4247.5	9524	–	34,041	17,939.6	62.6	–	52,043.2
1990	620.8	19,560.5	20,181.3	3920.9	20.8	–	–	3941.7	10,192.3	–	34,315.3	23,147.6	80.1	–	57,543
1991	998.4	20,563.1	21,561.5	3291	2.2	–	–	3293.2	12,588.6	38.4	37,481.7	22,683.3	81.3	–	60,246.3
1992	1814.6	22,756.2	24,570.8	5271.3	1.7	–	–	5273	10,813.7	47.1	40,704.6	26,568	69.6	–	67,342.2
1993	1796.1	21,963.8	23,759.9	5171.4	3.1	–	–	5174.5	10,788.2	56.4	39,779	33,950.9	77.6	–	73,807.5
1994	1977.6	26,257.1	28,234.7	5546.8	2	–	–	5548.8	13,822.3	50.9	47,656.7	30,585.9	79.1	–	78,321.7
1995	2232.1	25,814.8	28,046.9	5498.2	273.8	–	–	5772	16,579.3	222.3	50,620.5	35,540.9	86	–	86,247.4
1996	2574.1	27,839.5	30,413.6	6174.4	365.2	–	–	6539.6	17,174.2	175.4	54,302.8	40,475.2	83.7	–	94,861.7
1997	3272.8	30,587.2	33,860	6520.7	531.4	105.2	–	7157.3	22,085.6	294	63,396.9	39,816.1	82.8	–	103,295.8
1998	2980.9	32,706.6	35,687.5	7275.6	308.6	222.2	116.9	7923.3	24,837.5	254.6	68,702.9	42,229	85	5.5	111,022.4
1999	3122.8	33,908.1	37,030.9	6472.4	747.7	277.5	581.9	8079.5	36,345.9	204.7	81,661	34,677.5	80.9	20.5	116,439.9
2000	3819	34,367.3	38,186.3	7459.1	980.6	324	547.1	9310.8	46,216.9	220.2	93,934.2	30,878.5	75.5	33.4	124,921.6
2001	4046	34,371.5	38,417.5	8816.6	904	162.1	483.5	10,366.2	49,549.2	229.9	98,562.8	24,009.9	89.6	62.4	122,724.7

Table 7
Annual development of Turkey's gross electricity generation by share of primary energy resources (%) [49]

Years	Hard coal	Lignite	Fuel oil	Diesel oil	LPG	Naphtha	Renew. and waste	Natural gas	Thermal	Hydro	Geothermal	Wind
1970	16.00	16.70	27.10	3.10	–	–	1.90	–	64.80	35.20	–	–
1975	9.10	17.20	30.10	4.40	–	–	1.40	–	62.20	37.80	–	–
1980	3.90	21.70	22.40	2.60	–	–	0.60	–	51.20	48.80	–	–
1981	3.60	21.30	21.10	2.50	–	–	0.40	–	48.90	51.10	–	–
1982	3.40	20.80	20.00	2.40	–	–	–	–	46.60	53.40	–	–
1983	2.90	28.50	23.20	3.90	–	–	–	–	58.50	41.50	–	–
1984	2.30	30.70	21.90	1.10	–	–	–	–	56.00	43.90	0.10	–
1985	2.10	41.80	20.50	0.20	–	–	–	0.20	64.80	35.20	0.00	–
1986	2.00	47.00	17.50	0.10	–	–	–	3.40	70.00	29.90	0.10	–
1987	1.40	38.40	12.20	0.20	–	–	–	5.70	57.90	42.00	0.10	
1988	0.70	25.30	6.80	0.10	–	–	–	6.70	39.60	60.30	0.10	
1989	0.60	38.30	8.10	0.10	–	–	–	18.30	65.40	34.50	0.10	–
1990	1.10	34.00	6.80	–	–	–	–	17.70	59.60	40.20	0.20	–
1991	1.70	34.10	5.60	–	–	–	0.10	20.80	62.30	37.60	0.10	–
1992	2.70	33.80	7.80	–	–	–	0.10	16.00	60.40	39.50	0.10	–
1993	2.40	29.70	7.00	–	–	–	0.10	14.60	53.80	46.10	0.10	
1994	2.50	33.50	7.10	–	–	–	0.10	17.60	60.80	39.10	0.10	–
1995	2.60	29.90	6.40	0.30	–	–	0.30	19.20	58.70	41.20	0.10	–
1996	2.70	29.30	6.50	0.40	–	–	0.20	18.10	57.20	42.70	0.10	–
1997	3.20	29.60	6.30	0.50	0.10	–	0.30	21.40	61.40	38.50	0.10	–
1998	2.70	29.50	6.60	0.30	0.20	0.10	0.20	22.40	61.90	38.00	0.10	–
1999	2.68	29.12	5.56	0.64	0.24	0.50	0.18	31.21	70.13	29.78	0.07	0.018
2000	3.06	27.51	5.97	0.78	0.26	0.44	0.18	37.00	75.19	24.72	0.06	0.06
2001	3.30	28.00	7.20	0.70	0.10	0.40	0.20	40.40	80.30	19.60	0.10	0.09

Table 8
Breakdown of installed electricity capacity in Turkey (MW) [48]

Institution	Sources	Years					
		1990	1995	1998	1999	2000	2001
Turkish electricity production company	Thermal	8246.7	6349.1	6763.1	8116.1	7973.1	7653.1
	Hydraulic	6465.1	9207.6	9497.9	9701.7	9977.3	10,108.7
	Geothermal	17.5	17.5	17.5	17.5	17.5	17.5
	Total	14,729.3	15,574.2	16,278.5	17,835.3	17,967.9	17,779.3
Cukurova electricity company	Thermal	106.0	106.0	106.0	–	–	–
	Hydraulic	192.0	482.7	482.7	482.7	482.7	482.7
	Total	289.0	588.7	588.7	482.7	482.7	482.7
KEPEZ electricity company	Thermal	80.4	127.6	127.6	127.6	127.6	127.6
Auto production	Thermal	1183.1	1334.9	2291.8	2632.0	2955.2	3319.4
	Hydraulic	10.80	9.70	13.60	21.90	39.2	53.0
	Wind	–	–	1.10	1.10	1.10	1.10
	Total	1193.9	1344.6	2306.9	2655.4	2995.9	3373.9
Production companies	Thermal	–	–	576.4	1444.6	1449.6	1449.6
	Hydraulic	16.0	35.2	184.7	203.3	518.3	870.8
	Wind	–	–	7.20	7.20	17.40	17.40
	Total	16.0	35.2	768.3	1655.1	1985.3	2337.8
Subsidiaries of Turkish electricity company	Thermal	–	3284.0	3284.0	3284.0	3284.0	3284.0
Mobile power plant	Thermal	–	–	–	79.2	90.6	297.0
Power plant whose operation right is transferred	Thermal	–	–	–	–	300.0	620.0
	Hydraulic	–	–	–	–	30.10	30.10
	Total	–	–	–	–	330.1	650.1
General total production	Thermal	9535.8	11,074.0	13,021.3	15,555.9	16,052.5	16,623.1
	Hydraulic	6764.3	9862.8	10,306.5	10,537.2	11,175.2	11,672.9
	Geothermal-wind	17.5	17.5	26.20	26.20	36.4	36.4
	Total	16,317.6	20,954.3	23,354.0	26,119.3	27,264.1	28,332.4

TEK had been included in the scope of privatization studies in 1993. August 13, 1993, which was issued 23 years after its founding whose relations with the MENR would be on going. As a continuation of this arrangement, it was split into two separate state owned

Table 9
Breakdown of electricity generation in Turkey (GWh) [48]

Institution	Sources	Years					
		1990	1995	1998	1999	2000	2001
Turkish electricity production company	Thermal	30,618	38,353	38,895	42,583	46,095	46,970
	Hydraulic	22,156	33,105	39,601	31,737	27,772	20,409
	Geothermal	80	86	85	81	76	90
	Total	52,854	71,544	78,581	74,401	73,942	67,469
Chartered companies	Thermal	346	–	–	–	–	–
	Hydraulic	959	2301	2299	2169	1903	1346
	Total	1305	2301	2999	2169	1903	1346
Auto production	Thermal	3,351	5,617	10,097	12,493	15,895	17,797
	Hydraulic	10	8	31	32	63	112
	Wind	–	–	4	4	4	4
	Total	3361	5625	10,132	12,529	15,962	17,914
Production companies	Thermal	–	–	2217	8469	10,936	11,151
	Hydraulic	23	126	298	739	1073	2071
	Wind	–	–	2	16	29	57
	Total	23	126	2517	9224	12,039	13,279
Subsidiaries of Turkish electricity company	Thermal		6651	17,494	17,911	19,292	18,894
Mobile power plant	Thermal	–	–	–	205	644	1117
Power plant whose operation right is transferred	Thermal	–	–	–	–	1073	2634
	Hydraulic	–	–	–	–	68	73
	Total	–	–	–	–	1141	2707
General total generation	Thermal	34,315	50,621	68,703	81,661	93,934	98,563
	Hydraulic	23,148	35,541	42,229	34,678	30,879	24,010
	Geothermal-wind	80	86	91	101	109	152
	Total	57,543	86,248	111,023	116,440	124,922	122,725
Imports	Bulgaria	–	–	2317	1798	3297	3776
	Ex-USSR	54	–	–	–	–	–
	Georgia	122	–	779	239	205	523
	Iran	–	–	202	292	290	281
	Total	176	–	3299	2330	3791	4579
Exports	Total	907	696	298	285	437	433

enterprises, namely 'Turkish Electricity Generation Transmission Co. (TEAS)' and 'Turkish Electricity Distribution Co. (TEDAS)', by the Act of the Council of Ministers [25].

Regulation 85/9799, published in the Official Gazette on 4 September 1995 and numbered as 18,858: this consists of permission and authorization of the autoproduction owners (individuals and institutions) who establish electricity production facilities and produce electricity for meeting their own needs and requirements for preparing feasibility reports. Regulation 96/8007, published in the Official Gazette on 17 April 1996 and numbered as 22,614: this consists of the regulations related to 'who will be authorized', 'over production and its selling price', 'transmission and distribution cost of produced energy to other facilities'. Regulation 97/9670, published in the Official Gazette on 2 September 1997 and numbered as 23,068: this consists of regulations related to housing development projects, over 5000 houses, hospitals, compulsory usage of waste heat and steam, waste energy sales, fuel usage and trade terms, and the rights of autoproduction firms [26]. Law no. 4283, issued in 1997, facilitated the BO model. Under BO, the developers retain ownership of the plant and can sell the electric power to an end user, the state-owned electric authority, or the national grid [27].

In February 2001, Turkey passed the long-anticipated Electricity Market Law, which paves the way for a free market in power generation and distribution in the country. Among other things, the legislation calls for: (1) TEAS (the Turkish Electricity Generation and Transmission Corporation) to be broken up into separate generation, distribution, and trade companies; (2) trade and generation companies to be privatized, while transmission remains in state hands; and (3) a new regulatory board to be set up which will oversee the Turkish power market, set tariffs, issue licenses, and prevent uncompetitive practices. The new law throws into doubt the fate of dozens of BOT and TOR (transfer-of-operating-rights) power projects [28,29]. By Electricity Market Law no. 4628, issued in the Official Gazette dated 3rd March, 2001, concerning the restructuring of the energy sector, the establishment of financially strong, stable and transparent electricity market under competitive and special law provisions has been targeted for a sufficient, high-quality, continuous, low-cost and environment friendly supply of electricity to the disposal of consumers as well as the maintaining of an independent regulatory and supervisory framework. This law covers the generation, transmission, distribution, wholesale, retail and respective services of electricity including its import-export and also the rights and responsibilities of all real and legal persons connected with those services and establishment of a Regulatory Body of Electricity Market and its running procedures and principals as well as the procedures to be followed for the privatization of the electricity generation and distribution assets. By the Decree of Council of Ministers No. 2001/2026 and dated February 5, 2001, which was issued in the Official Gazette dated 2nd March, 2001, TEAS was decided to be restructured to form three state-owned public enterprises, namely Turkish Electricity Transmission Co. (TEIAS), Turkish Electricity Generation Co. (TEUAS) and Turkish Electricity Trading and Contracting Co. (TETTAS) [30].

In May 2002, the EMRA (Energy Market Regulatory Authority) issued drafts of the Energy Market Licensing Regulation and the Electricity Market Tariffs Regulation, and these regulations went into effect in August 2002. The EMRA has announced a fourstage approach to a competitive electricity market. The first stage grants licenses to firms in the electricity and natural gas markets, while the second stage, which is expected to start March 3, 2003, will give large industrial users the right to choose their electricity provider. The third stage will start to set up the Market Financial Reconciliation Center for balancing and settlements and the fourth stage will make this Center fully operational. Legislation has been proposed in the Turkish parliament that would expand the scope of

the EMRA to include the upstream activities in the petroleum market. This Petroleum Market Bill is expected to be considered by the parliament in the near term [31].

Today, there are five types of investment models in operation in Turkey: (a) the build operate and transfer (BOT) model; (b) build own operate (BOO) model; (c) the autoproducer model; (d) the transferring of operating rights (TOOR) model. The first three models (BOT, BOO, auto-producer) have been used to obtain private investment in new power plants. The TOOR model has been used to try and concession existing generating assets and distribution companies to private investors. The BOT and BOO approaches attracted substantial new investment in power plants. However, the energy prices from BOT plants are extremely high, and both approaches have created huge contingent public obligations with the government covering the market risk through take-or-pay contracts. The auto-producer model, which is essentially a form of self-generation employed by industries who also sell surplus energy to the national grid, is in many respects the most successful as it has created a large amount of capacity without any associated public liabilities [32].

A license is an authorizing document that a legal entity should obtain from the EMRA in order to operate in the market. In order to operate in the market, legal must obtain the relevant license for each market activity and for each facility. According to the Law, licensees may be engaged in the following market activities: (a) generation; (b) transmission; (c) distribution; (d) wholesale; (e) retail and retail service; (f) import and export. The import and export activities to be undertaken by wholesale licensees and import activities to be undertaken by the retail licensees shall be regulated within the scope of their wholesale or retail licenses and no separate license shall be required. In Turkey, the generation activity shall be performed by the state-owned Electricity Generation Company (EUAS), its affiliates, private generation companies, autoproducers and autoproducer groups. The generation licensees may sell the generated electricity and/or capacity to wholesale licensees, retail licensees and eligible consumers through bilateral contracts. The transmission activity in the market shall be performed by the Turkish Electricity Transmission Company (TEIAS). Holding the ownership of all transmission assets, TEIAS shall serve as the transmission system operator and the market operator. The distribution activity shall be performed by the Turkish Electricity Distribution Company (TEDAS), its affiliates and private sector distribution companies in the regions specified in their licenses. The wholesale activity shall be performed by TETAS and private sector wholesale companies. Retail and/or Retail Services are performed by retail companies and distribution companies holding a retail license [33].

4. Development of electricity consumption in turkey in the past and expectation for the future

Turkey's electricity demand grew quickly in the past and is still growing rapidly. Therefore, the government is well advised to secure electricity supplies to enable the country to industrialize and increase the living standards. The rapid growth from a low base suggests that Turkey still has to catch up with the industrialized nations in terms of economic development and industrialization. The development gap between Turkey and the industrialized nations is not yet closed and future economic growth will in all likelihood be matched by strong growth in electricity demand.

Average annual growth rates of power consumption have been 8% or higher for decades. Turkey had about 31.84 GW of installed generating capacity in 2002, but for

Table 10
Future projection of the population and electricity consumption per capita in Turkey [48,51]

	Years				
	2003	2005	2010	2015	2020
Population (million)	70.77	73.1	78.46	83.34	87.76
Electricity consumption/population (kWh per capita)	2413.45	2730.51	3693.60	4761.46	6234.5

years has had problems supplying the rapidly growing demand, leading to frequent power cuts during peak times. The winter peak season was expected to see a shortfall of available generating capacity of up to 7 TWh, because of the combined effects of renewed strong growth in economic activity and electricity demand after the severe 1998/99 recession.

Turkey's Net Electricity Consumption increased from 29.7 TWh in 1985 to 103.30 TWh in 2002. The growth in electricity generation in recent years was below growth in electricity demand. Turkey is a net importer of electricity. Owing to the country's strong power demand growth, net electricity imports have increased considerably since 1996. While there was no electricity import of Turkey in 1995, it increased to 4579 GWh in 2001. Turkey exports small amounts of electricity to Azerbaijan. However, compared to total power supply levels, Turkey's power imports are insignificant ($<0.3\%$) (see Table 3). The electricity demand per capita, which was realized as 1013 kWh in 1990, 1417 kWh in 1999 will increase to 6794 kWh in 2020 (see Table 10) [34]. Per capita electricity consumption of Turkey will be still low when it is compared with average of OECD countries with 7326 kWh (See Table 2).

The MENR has planned for a very large increase in electric generating capacity over the next 20 years. According to forecasts prepared by the Ministry of Energy and Natural Resources (MENR), the country will need about 65 GW of capacity by 2010, and about 109 GW by 2020. The generation capacity was 122.11 TWh in 2002 and planned to reach 242.8 TWh in 2005, 347 TWh in 2010 and 624 TWh in 2020. The electricity demand which was 103.30 TWh in 2002, is expected to be 200 TWh in 2005, 290 TWh in 2010 and 547 TWh in 2020 growing by 5 times in 20 years time (see Table 11).

As a result of technological innovation and an assumed shift in the industrial structure towards less energy intensive industries in Turkey, it is expected that the share of the industrial electricity consumption can decrease in the future. In the residential/commercial-official sectors, energy demand growth will be increased by the further penetration of electrical appliances due to the increase of living standards. The level of electrical appliances has grown at high rates in the last decade, mainly as a result of increasing income levels. The electrification in rural area and the penetration of refrigerators, washing machines, television sets, radios, electric fans and air condition has increased the electricity consumption in both urban and rural households. Based on these past trends and expected strong growth in income per capita, it is very likely that penetration of many appliances will continue to grow and strongly affect the future trends of electricity demand.

5. Power generation and the share of the energy resources

Turkey's electricity generation in Turkey is based on hydro power and fossil generation. Tables 6 and 7 shows the development of electricity generation by fuel type between 1970

Table 11
Future projection of Turkish electricity production and consumption balance [48,51]

Sources	Years									
	2003		2005		2010		2015		2020	
	MW	Billion kWh	MW	Billion kWh	MW	Billion kWh	MW	Billion kWh	MW	Billion kWh
Thermal	24,854	161.6	27,654	179.8	40,134	261.9	56,834	372	79,234	520
Hydrolic	14,236	50.5	17,981	63	24,935	85.4	28,806	99.1	29,984	103.7
Total production	39,090	212.1	45,635	242.8	65,069	347.3	85,640	471.1	109,218	623.7
Total consumption	27,261	170.8	31,850	199.6	46,219	289.8	64,122	398.2	88,100	547.1

Table 12
Selected renewables indicators by country for 2001 [47]

	Total Primary Energy Consumption (Mtoe)	Of which renewables (Mtoe)	Share of renawables in TPES (%)	Share of the main fuel categories in total renewables (%)		
				Hydro	Geothermal, solar, wind, tide	Combustible renewables and waste
Austria	30.7	6.6	21.5	54.4	1.6	44
Germany	351.1	9.2	2.6	19.2	11.7	69.1
Italy	172	9.6	5.6	41.8	34.3	24
Portugal	24.7	3.4	13.7	35.5	3.9	60.6
South Korea	194.8	2.2	1.1	16.4	2.1	81.5
Spain	127.4	8.2	6.5	42.8	7.8	49.4
United Kingdom	235.2	2.5	1.1	13.7	3.8	82.4
Turkey	72.5	9.4	12.9	22.1	10.6	67.4
OECD	5332.8	303.7	5.7	34.8	11.6	53.6
World	10,038.3	1351.9	13.5	16.4	3.7	79.9

and 2001. The share of hydroelectric generation in gross electricity output stood at about 40% throughout the 1990s, but is expected to decline in future, and is subject to fluctuations in proportion to rainfall. Its share in 2001 was 19.6% (24 TWh), down from 38% the preceding year. In 2001, coal accounted for 31.3% (38.4 TWh), oil for 6.8% (9.7 TWh), and gas for 40.5% (49.6 TWh) (see Tables 6 and 7).

Some renewable indicators for the selected country have been shown in Table 12. Renewable energy usage of Turkey is quite reasonable when it is compared to selected countries given in the Table. Share of renewables in Total Primary Energy Consumption (TPES) is 12.9% in Turkey. Turkey's combustible renewables and waste share is 67.4% in total renewables. Hydro has the second big share with 22.1%. Share of electricity production from renewable sources for selected countries between 1990 and 2001 was given

in Table 13. Hydroelectricity is one of the most important renewable sources for electricity generation in Turkey. Although its share decreased from 40.4% in 1990 to 19.8% 2001, it is still above the average of European Union, which Turkey is expecting to be a member (see Table 13).

5.1. Fossils fuels and nuclear

5.1.1. Lignite and hard coal

Conventional energy resources are widely used for electricity power generation in Turkey. Currently there are 15 coal-fired thermal plants in Turkey. In fact, coal is a highly efficient and cheap resource of energy for Turkey, also plentiful coal resources exist in Europe, but the quality of the lignite is not high and is suitable for use in the power plants. Advanced technologies can be used burning these lignites. The total lignite reserve of Turkey is nearly 8.3 billion tons but the reserve that can be processed is 3.9 billion tons. Turkey's coal reserve is 1.1 billion tons but the amount that can be processed is 0.4 billion tons [35]. Nearly all coal used in power generation is domestic lignite (28% out of 31.3%); imported hard coal accounts for only 3.3%. Use of domestic lignite and imported hard coal in industry and power generation appears exaggerated. The power sector accounts for the largest coal demand and consumes mainly lignite. Almost 80% of lignite production is used in power plants. In contrast, less than 9% of hard coal supply is used for power generation. Turkish government expects total coal supply to rise from 20.1 Mtoe in 1999 to 118.4 Mtoe in 2020; more than five times higher than current figures. Behind this increase lies the expectation of tremendous growth in hard coal and lignite fired power generation, and in industrial use of coal.

Hard coal is found and mined in only one location, the Zonguldak basin near the northwestern Black Sea coast. On the other hand, lignite is found in almost all regions of the country. Hard coal production has declined since the mid-1980s, falling from 2.7 million tones in 1990 to 2 million tones in 1999. Turkish Hard Coal Cooperation (TTK) has a de facto monopoly in hard coal production, processing and distribution. There are no legal restrictions on operations by the private sector, but the operating conditions are too unattractive for private capital.

The total lignite reserves are estimated as 8075 Mtoe, of which 7339 Mtoe (88%) is economically feasible and 34 of lignite capacity is being worked [36]. About 40% of Turkey's lignite resources, or 3.4 billion tones, are situated in Afsin-Elbistan basin in the south-eastern part of Turkey. Much of the remainder and over half of all lignite production are located in the western parts of Turkey. The fully state-owned enterprise Turkish Lignite Enterprise (TKI) was responsible for about 56% of lignite production in 1998. Private companies produce about 10% of the total. The remainder is produced by two open-cast lignite mines that are owned by the state-owned electricity company TEAS and supply lignite to three lignite-fired power plants, Sivas-Kangal, Afsin-Elbistan and Cayirhan. Oil provided 7% of electricity generation, predominantly peak load.

5.1.2. Oil

Oil provides nearly half of Turkey's total energy requirement but gradually it is leaving its place to natural gas. Around 90% of Turkey's oil supplies are imported mainly from the Middle East and Russia. The total oil reserve of Turkey is 931 million tons [35]. The

Table 13
Share of electricity production from renewable sources for selected countries between 1990–2001 [47]

	Years											
	1990		1995		1998		1999		2000		2001	
	Including hydro	Excluding hydro	Including hydro	Excluding hydro	Including hydro	Excluding hydro	Including hydro	Excluding hydro	Including hydro	Excluding hydro	Including hydro	Excluding hydro
Austria	66.2	2.3	70.5	3.3	69.4	2.9	71.4	3.1	72.3	2.8	70.1	3.1
Germany	3.7	0.6	5.1	1	4.8	1.3	5.2	1.7	6.3	2.5	6.2	2.7
Italy	16.4	1.6	17.5	1.6	18.4	2.2	19.9	2.4	18.9	2.5	20.1	2.9
Portugal	34.7	2.5	28.3	3.2	36.4	3	20.3	3.4	30.3	4.2	34.6	4.2
South Korea	6	–	1.7	0.1	2.2	0.2	1.9	0.2	1.7	0.2	1.6	0.1
Spain	17.2	0.4	14.9	0.9	19.3	1.7	13.5	2.4	16.3	3	21.9	4.4
United Kingdom	1.8	0.2	2.1	0.6	2.4	1	2.6	1.2	2.6	1.3	2.5	1.4
Turkey	40.4	0.1	41.6	0.4	38.3	0.3	30	0.2	24.9	0.2	19.8	0.2
European Union	13.1	0.9	14	1.4	14.3	1.9	14.2	2	14.9	2.4	15.5	2.7
OECD	17.3	1.8	17	1.7	16.5	1.8	16.1	1.9	15.7	2	15	2.1
World	17.4	1.7	17.2	1.7	16.6	1.8	16.2	1.9	15.8	1.9	15.1	2.1

share of oil in electricity generation was about 30% in 1970 and decreased to about 8% in 2001.

5.1.3. Natural gas

Natural gas is the fastest growing primary energy source in the world. In Turkish energy market, the gas industry stands out as particularly fast-growing. The tremendous growth in gas demand during the 1990s showed that Turkey will need much more gas in the next few years. The share of the use of natural gas in power generation increased sharply in last 15 years and reached to about 41% in 2001. In September 2002, two new combined cycle gas-fired power plants (the 770 MW Adapazari and 1540 MW Gebze facilities) came online, ahead of schedule. A third, 1525 MW, gas-fired plant was scheduled to come online in December 2002 at Izmir. Finally, Tractabel is scheduled to complete a 763 MW gas-fired plant at Baymina, near Ankara [29]. It is projected that the power sector dominates the expected demand development, while residential and industrial sectors will also indicate a significant growth in natural gas consumption. Of sectoral total, 68.5% is expected to be used by power plants by 2020, with the industrial sector at 18.3%, residential at 12.1% and fertilizer at 1.1% [21].

5.1.4. Nuclear

There is also the possibility of a nuclear power plant. The Turkish government has just declared that nuclear power plant with a total capacity of 1300 MW would be built at Akkuyu in 2012 [29]. However, it seems that oppositions from environmental and antinuclear groups resist this plan like before. In fact, most European countries lean towards becoming increasingly nonnuclear in the future, basic reason being the large quantities of highly radioactive waste these plants generate. A major part of Turkey's land is in the seismic zone. However, Turkish government is still considering to establish the nuclear power plant to overcome the possible high electricity demand in the future.

5.2. Renewables

Achieving sustainable development is a target that is now widely seen as important to worldwide public opinion. In this regard, the utilization of renewable energy resources, such as solar, geothermal, and wind energy, appears to be one of the most efficient and effective ways in achieving this target. Recently, wind power as a potential energy has grown at an impressive rate in Turkey [25]. In March 2004, the World Bank granted Turkey a $200 million Energy Reform Loan to encourage the use of renewable energy in the country [29].

Renewable, except hydraulic, have only very minor shares in power generation in Turkey: geothermal accounts for 0.1% or 89.6 GWh, wind for about 0.09 or 62.4 GWh and combustible renewable for about 0.2% or 49.5 GWh. Economically-feasible renewable energy potential in Turkey is estimated at a total of capacity 495.4 TWh/yr with the potential for 196.7 TWh/yr of biomass energy, 124 TWh/yr of hydropower, 102.3 TWh/yr of solar energy, 50 TWh/yr of wind energy, and 22.4 TWh/yr of geothermal energy. Pursuit and implementation of sustainability-based energy policy could provide about 90 and 35% of Turkey's total energy supply and consumption projected in 2010, respectively.

Utilization of renewable energy technologies for electricity generation would necessitate about 23.2 Mha (29.8%) of Turkey's land resources.

5.2.1. Hydro

Turkey's second largest energy source after coal is hydro. The three largest dams in Turkey are the 2400 MW Ataturk dam, the sixth-largest rock fall dam in the world, on the main trunk of the Euphrates; the 1800 MW Karakaya dam; and the 1200 MW Ilisu dam, the largest hydro project on the Tigris River. In 1999, there were 114 hydroelectric power plants in operation in Turkey. In 2001, Total hydroelectric power plant capacity in Turkey was 11,672.9 MW, with estimated mean annual generation of 24 TWh. In addition, some 37 hydro plants with a total capacity of 4057 MW are under construction, corresponding to about 13.4 TWh of additional annual power generation. In 2005, the 1440 MW Afsin-Elbistan B Thermal Power Plant will open in southern Anatolia, southwest Turkey and contribute an estimated 7.5% of the country's predicted electricity generation needs [37]. The Turkish government hopes that hydro capacity will expand to 35,000 MW by the year 2020. The government expects the construction of 332 more hydro plants in the long term to make use of the potential remaining hydro sites. This would bring the number of hydro plants to 485, and add more than 19 GW of capacity to the hydro system. This increase in the hydro generating capacity includes the Southeastern Anatolia Project (GAP) that covers one-tenth ($74,000\,km^2$) of Turkey's total land area, one of the largest hydro developments ever undertaken. Upon its completion, GAP will have an installed capacity of 7476 MW. The construction of all these new dams requires an investment of more than US$ 30 billion [38].

5.2.2. Wind

Wind energy is the fastest growing energy source in the world and wind power is one of the most widely used alternative sources of energy today. It is a clean and renewable source of electricity [39]. With an annual average wind speed and power density of about 2.5 m/s and 25.8 W/m^2, respectively, the western, northern and south-eastern coasts of Anatolia have been identified as very favorable locations for wind power generation in Turkey. Electricity generation through wind energy for general use was first realized at Cesme Altinyunus Resort Hotel (The Golden Dolphin Hotel) in Izmir, in Turkey in 1986 with a 55 kW nominal wind power capacity [40]. Between 1986 and 1998, there were some attempts to generate electricity from wind, but they were never successful. The first wind power facility with a total installed capacity of 1.5 MW, excepting to the small wind system with a capacity of 55 kW, commissioned in February 1998 is located near the city of Izmir at Cesme Germiyan in western Turkey. In November 1998, ARES (Alacati Wind Energy Plant) which has 12 wind turbines for a total capacity of 7.2 MW was commissioned [38]. The biggest available wind energy power plant in Turkey is the BORES (Bozcaada Wind Energy Plant) with 10.2 MW power, is to be sold after repaying its cost. It was constructed in January 2000 and uses 17 wind turbines. Each turbine has 600 kW power. This facility generates 35 million kWh electric energy per year [41]. In 2001, the electricity generation from the wind was reached to 62.4 GWh. Turkey have 20.1 MW of wind power installed capacity, up from the current national capacity of 18.9 MW obtained from three wind power plants [25]. In addition to above operating power plants, many individuals apply to the Ministry of Energy and Natural Sources to generate wind energy. The current production status of wind energy projects in Turkey is between 727.96 and 817.96 MW

[41]. The majority of wind energy projects are concentrated in the Aegean (16 projects) and Mediterranean regions (9 projects). The installed capacity of wind energy is expected to reach 600 MW by 2010 and 1000 MW by 2020. Theoretically, Turkey has 160 TW h a year of wind potential, which is about twice as much as the current electricity consumption of Turkey [39].

5.2.3. Solar

Turkey lies in a sun belt between 36 and 42°N latitudes. The yearly average solar radiation is 1303 kWh/m^2 year and the total yearly radiation period is approximately 2623 h. Solar energy can technically and economically be harnessed during 10 months over 63% of the land area, whereas 17% of the land area can be used during the entire year. In spite of this significant potential and the proper conditions for solar energy applications, the present contribution of solar energy to the total energy budged is at a negligible level. Photovoltaic (PV) power applications in Turkey are sorely limited with some state organizations use PV for meeting remote electricity demand. The main application areas include telecom stations, fire observation stations, lighthouses and highway emergency systems. Total installed power is nearly 300 kW. Solar electricity production via PV (solar cells) does not appear to increase in the near future since Turkey, currently, does not have an organized photovoltaic (PV) program [42,43].

5.2.4. Geothermal

Turkey is the seventh richest country in the world in geothermal potential for its direct use and for electricity generation. Based on the values for wells drilled, Turkey's geothermal power production potential is estimated to be 764.81 MW. The only operating geothermal power plant of Turkey is the Denizli-Kizildere Geothermal Power Plant (DKGPP), located near the province of Denizli in Western Anatolia with an installed capacity of 20.4 MW [44]. The DKGPP was put into operation in 1984 and has been operated since then. It produced an electrical energy of 89,597 MWh in 2001, representing an electric power of 10.6 MW in the same year. Other high-temperature geothermal fields suitable for conventional electricity generation are Aydin-Germencik (230 °C), Canakkale-Tuzla (173 °C), Aydin-Salavatli (171 °C), and Kutahya-Simav (162 °C). There are also potential geothermal fields, such as Seferihisar, Salihli, Dikili, and Golemezli, for electricity production. These fields may be evaluated if the government offers the financial and/or institutional support that is required for successful development [45]. Electricity generation projections of Turkey are also 500 MW from Germencik, Kizildere, Tuzla and several of the other fields by the year 2010 and 1000 MW by 2020 [46].

5.2.5. Biogas

Biogas production potential has been estimated at 1.5–2 Mtoe but neither the government nor the private sector has yet expressed any interest in using this resource. There are two BOT power plant projects using biogas (Ankara and Adana waste-to-power plants), but not much progress has been made and the government fears the projects will lapse. There is one autoproducer waste-to-energy power plant in operation in Izmit. This plant was commissioned in 1998 and has an installed capacity of 5.4 MW. A contract has been signed for another autoproducer plant of 5.4 MW in Istanbul, to be constructed by the municipality of Istanbul [3,47].

Table 14
Net power generating cost by energy input [52]

Fuel input	Cost (US cents per kWh)
Hard coal	4.37
Lignite	2.99
Fuel oil	3.14
Diesel	16.24
Geothermal	2.46
Natural gas	3.86
Average thermal (EUAS)	3.56
Dam	0.14
Lake	1.11
Run-of-river	0.68
Average hydro (DSI)	0.16
Average EUAS + DSI	1.96

6. Conclusion

Electricity consumption in Turkey has been growing very rapidly. To cope the expected increase in electricity consumption, electricity generation capacity must increase. Since 1996, Turkey has become a net importer again. Turkey was a small net exporter of electricity, mainly to Azerbaijan (Nakhichevan) due to political reason. The electricity losses in transmission and distribution amounted to average of 16% of net electricity generation during 1985–2001 highest record of OECD. The use of natural gas for power generation increased to 41% in a very short time although it is projected to be as 26% in 2000 and 31% in 2020. The share of hydroelectric (renewable) and lignite (national resource) was decreased while the share of natural gas in electricity generation increasing. According to EUAS and DSI for the data of 1999, Turkey's net electricity power generating cost by energy input is shown Table 14. Hydro is the cheapest electricity resources in term of cost.

Turkey has limited reserves of oil and natural gas, but proven reserves of lignite in the order of 8.4 billion tones. In Turkey, lignite is cheaper than natural gas as an input fuel for the industry, but gas-using equipment tends to have lower capacity cost, can be built in smaller increments and have a short time high profit that forced to increase the natural gas use.

The electricity consumption rate in the past was showed that it will continue to increase in the future due to the increase of the population, the change of social and economic development and urbanization. Therefore, the installation of the electricity power plant will be very important for the near future.

The transmission and distribution losses steadily increased in Turkey and it was increased to 23,328.7 GWh in 2001. The share of the transmission and distribution losses in total consumption was increased to 19.3% in 2001 which was 14.5 in 1985. It is very high and should be decreased in the future.

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